394

Methods of Drying Sumac*

A. F. Sievers [1] and I. D. Clarke [2]

United States Department of Agriculture
Beltsville, Maryland

Introduction

The usefulness of three of the native species of sumac, *Rhus copallina* L. (dwarf sumac), *R. glabra* L. (white sumac), and *R. typhina* L. (staghorn sumac) as sources of tannin has long been known and for a hundred years or more the leaves of these, especially of the first two species, have been collected for that purpose in some of the Eastern States. The leaves of a European species, *R. coriaria* L., known as Sicilian sumac, are imported from Italy for the same purpose. The consistently higher quality of this imported product has discouraged the development of the domestic sumac industry but the reason for any wide difference in value is easily understood. Domestic sumac is generally gathered and dried under conditions that cannot result in a uniform product of acceptable quality and until the handling of the material, especially the drying of it, is more widely conducted by approved methods, no substantial improvement in the situation may be expected.

A wider utilization of the native stands in regions where the species are abundant would result from better handling practices and there is the possibility also that this would lead to the growing of the species as cultivated crops on eroded lands. These sumacs are excellent erosion control plants and are therefore well adapted to use in soil conservation practices on eroded areas if methods of handling the crop that are practical on small farms can be devised so that the value of the marketed product will be equal to or approach that of the imported sumac.

The value of sumac in the tanning and dyeing of leather depends on several conditions. The tannin content, the ratio of tannin to non tannin and the color of the leaf are the most commonly recognized characters on which the value of the product is based. Many factors determine and modify these characters most of which are subject to control through rational practices in the collection and handling of the leaves. Investigations of methods of harvesting and drying the sumac whether the source is wild stands or the cultivated crop may therefore provide the basis on which practical methods of handling the product may be determined.

*This paper reports the results of one phase of the cooperative investigations of American sumac as a commercial source of tannin by the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration and Soil Conservation Service, U. S. Department of Agriculture.

1 Bureau of Plant Industry, Soils and Agricultural Engineering, Beltsville, Md.

2 Bureau of Agricultural and Industrial Chemistry.

Credit is due E. T. Steiner formerly of the Bureau of Agricultural and Industrial Chemistry, C. S. Britt, and Henry Hopp of the Soil Conservation Service and S. B. Detwiler, formerly of that service for their collaboration and assistance in these investigations.

The part that the domestic sumacs, wild or cultivated, could play in augmenting the nation's requirements of tannin is pointed out by Frey and Sievers [4] in discussing a cooperative program of research by government agencies on the development of new sources of domestic tanning materials believed necessary in view of the rapid depletion of the supply of chestnut wood which is the most important domestic raw tanning material. When this program was organized one phase of the investigation called for a thorough study of the quality of domestic sumac in relation to methods of harvesting and drying the leaves These were to be followed by field tests of practical and economical procedures for handling sumac and the use by tanners of material thus obtained for the tanning of skins by commercial practices. Such investigations it was expected, would provide an adequate basis for making recommendations to collectors and growers on the handling of sumac which would improve the quality so that its higher market value would lead to a greater utilization of this source of tannin supply. The war, in preventing the importation of Sicilian sumac, gave greater emphasis to the need for such investigations.

Review of the Principal Literature

A review of the many reports on the collection and utilization of these native sumacs in this country shows that the importance of carefully drying the leaves to prevent spoilage and assure a uniform acceptable color was recognized. However, this knowledge was mainly based on general observation since there is little to be found in the earlier literature regarding the specific effect of various practical farm methods on the quality of the dried sumac as determined by analysis and tests on leather. Veitch, Rogers and Frey [5] list a number of such conditions in connection with drying that result in poor sumac based mainly on general observations rather than on experimental evidence. They mention undue exposure to the sun, exposure to dew or rain and heating and molding in deep layers. To obtain the brightest product, they claim, the sumac is not allowed to wilt in the sun but is spread at once on racks in the barn or under cover.

Laboratory experiments by Clarke and Hopp [2] conducted in connection with the cooperative research program referred to, sought to determine the basic causes of the deterioration that takes place so readily when sumac is handled by the average collector. In these experiments comparable leaf samples of dwarf sumac were dried under a wide range of conditions by ten different methods and then subjected to chemical analysis and to tanning tests on pieces of sheepskin. The principal conclusions of the authors are: (1) The tannin content of separated leaves was not significantly influenced by the rate of drying at ordinary temperatures; heat treatment, such as in an oven or autoclave, reduced the tannin if heating was prolonged or at a high temperature; (2) sugars, both reducing and total, were significantly influenced by the drying method. Drying in the air resulted in a loss of sugar that was approximately proportional to the drying time. Oven drying also caused a loss of sugar. Changes in sugar content appeared to be the main cause of the variations in non tannins and purity; (3) the data indicate that a desirable light-colored leather generally comparable in this respect with that produced from Sicilian sumac, can be obtained if the leaves are dried rapidly, either by spreading them out in the sun or in an oven with artificial heat. The production of undesirable dark-colored leather from dwarf sumac appears to be associated with decomposition products formed within the leaves during slow drying; (4) brief steaming of the leaves, as in an autoclave, likewise gave light-colored leather even if subsequent drying was not rapid, apparently because the leaves were killed immediately and decomposition did not take place; (5) domestic sumac can be used for the production of light-colored leather if dried rapidly after harvesting.

Clarke, Mann and Rogers [3] have reported on extensive large scale tanning tests of the three American species on sheepskin skivers in comparison with the imported Sicilian sumac in collaboration with a commercial tannery. The material used consisted of leaflets and leaves obtained from various sources by various drying methods. Since these tests were made by a commercial tanner by commercial procedures the opinion of the tanner concerning the relative value of the several species is of special interest. He stated as follows:

"There are varieties of native American sumac which, if properly collected and prepared, can be used for tanning skivers which compare favorably with those tanned with Sicilian sumac.

"The tanned skivers are not quite equal in shade, weight and feel but can be used to replace those tanned with Sicilian sumac for most purposes.

"*R. copallina* (dwarf) gives the best results, *R. typhina* (staghorn) is second best and *R. glabra* (white) is poorest. The last tans slowly and apparently the tannin washes out of the leather when it is colored, which makes a tinny, harsh leather.

"On an equal price basis, Sicilian sumac will be preferred to American. If the quality of cultivated American sumac can be brought up to that of Sicilian, there should be no difference in price.

"Shade is not so important to the tanner as it is to the extract manufacturer. The tanner is more interested in weight and feel and requires a minimum of 26 per cent tannin in ground sumac but prefers 28 to 30 per cent."

Regarding the above conclusions of the tanner the authors of the report point out that on the basis of the physical tests made on the leather the order of preference of the three domestic species is dwarf, white and staghorn, but this evaluation included color, in which the tanner was not interested. On the whole, they found the difference between the three species not very great. The material used was obtained under relatively favorable circumstances with respect to drying conditions but even when purified by elutriation it did not yield a product fully equal to Sicilian sumac. The opinion is expressed that the best prospect of obtaining a product as good as Sicilian sumac is in breeding and propagating a variety better than any of the wild forms.

A valuable contribution toward the formulation of a practical procedure for drying sumac on a large scale was made by Barger and Aikman[1] in Iowa in 1942 and subsequent years when commercial quantities of white sumac were harvested by mechanical equipment in the southeastern section of the State, dried and shipped to eastern tanners. For drying large quantities a shed 20 x 64 feet was used. The side walls were boarded up about half way (8 feet). A mine-shaft fan forced unheated air through the material by means of a tapered tunnel the length of the shed with air vents in the sides and tops. The sumac was brought to the drier at intervals over a period of several weeks until the shed was full, and on each occasion spread uniformly. The partial drying which occurred between loadings made it possible to add the new green material each time without danger of any of the sumac heating. The outside air temperature varied from 50° to 80° F. and the relative humidity was very high for an average of 10 hours each night, dropping to an average low of 60 per cent during the day. During these periods the blower was operated an average of 6 hours per day. By this means the entire quantity was dry about a week after the last batch was added. The procedure followed and the results obtained indicate that the drier could be filled by three successive loadings of about one-third of its capacity at three day intervals and that the entire batch would be dry one week following the last loading.

A batch drier using heated air was also employed. A small structure 8 x 12 feet and 8 feet high was built over a common house furnace. A blower forced the air heated 10° to 12° F. above outside temperature through the 1600 pounds of green sumac with which the structure was filled. Charging, drying and emptying required two days. Tannin analysis of the leaves dried by these two methods showed that the more rapidly the leaf was dried the higher the tannin content, provided the leaf was not heated in excess of 140° F. The dried leaf samples were tested on small sheepskin skivers. The leather thus produced differed considerably in color. The lightest leather, which is the most desirable, was obtained with the leaf dried with heated air, the second best was obtained with leaf dried at a slower rate with unheated air in the large shed. The use of farmer-cured leaf of typical good and poor quality resulted in deeper colored leather.

Procedures and Results

A number of practical tests of drying methods, both laboratory and field, that were made in the past six years under the cooperative research program have furnished much useful information which has not been published. It is the purpose of this paper to bring together, in such detail as seems necessary, the principal data and conclusions in the hope that these will provide a better understanding of the problems involved in the handling of this product and thus result in an improvement in its quality with benefit to both producer and consumer. These several experiments were largely unrelated to one another and were not undertaken in any definite sequence and will therefore not be reported here in chronological order. First the laboratory or small scale experiments will be discussed and then those involving larger quantities and field operations or the use of commercial equipment.

Laboratory Experiments. Experiment 1: The relative effects of rapid and slow drying of dwarf sumac leaves at five temperature conditions ranging from 82° to 230° F. were determined. For this purpose the new growth from approximately 30 individual plants was collected on July 23. To assure uniformity of material used for each treatment, five lots were made of the total growth gathered by dividing the material collected from each of the 30 plants about evenly into five portions. One such portion was used for each of the five treatments, the quantity being in each case about 18 pounds. In three of these treatments the material as gathered was dried in an electrically heated drier at temperatures ranging from 125° to 230° F. as shown in Table I. In the other two treatments the sumac was dried on screens in the shade. After the drying was completed the leaves were removed from the stems, analyzed and used for skiver tests.

The data suggest that the leaves dried in 8 hours or less at temperatures ranging from 163° to 230° F. have a slightly lower tannin content than those dried on screens and a correspondingly higher non tannin content. Slower oven drying at not more than 154° F. for 17.5 hours gave about the same product except that it retained less of the green color than the screen dried product but more than the rapidly dried leaves. Drying on a screen in the attic in 4 days with a daytime maximum temperature of 118° F. yielded almost identically the same quality of product with respect to tannin and sugar content and green color as much slower drying on a screen at a maximum temperature of 90° F.

Experiment 2: In this experiment the leaves of dwarf, white and staghorn sumac were dried, (1) in a steam drier at temperatures ranging from 158° to 184° F., (2) on the second story floor of a wooden building (barn) and, (3) in a laboratory room. The dried leaves from the several lots were analyzed and their tanning quality was determined by tests on sheepskin skivers. The results are presented in Table II.

The non tannin content of the leaves of the three species did not vary much when dried by the several procedures The tannin content was from 1 to 1.4 per cent higher in leaves dried in thin layers in a room in which temperatures and humidity were controlled (Method 3). In general these limited experiments indicate that no important differences in leaf quality as determined by the usual chemical analysis resulted although the drying temperature and rate of drying varied widely.

TABLE I

Relative Quality of the Leaves of Dwarf Sumac (*R. copallina*) when New Growth Collected on July 23 Was Dried Rapidly at High Temperatures in Oven and More Slowly at Lower Temperatures on Screens in Rooms

Sample No.	Method of Drying	Time Required to Dry	Percentage of Leaf in Sample	Hue of Dried Leaf[1]	Chemical Analysis[2]: Total Extractives	Insolubles in Extractives	Soluble Extractives	Non Tannin	Tannin	Purity[3]	Sugars: Non-reducing	Reducing	Total	Reflectance at 546Mμ[4]
					Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
1	In oven at 183-230°F.	5.75 hrs.	83.9	5.42 Y	56.1	1.6	54.6	21.8	32.8	60.1	1.3	3.4	4.7	62.2
2	In oven at 165-169°F.	8.25 hrs.	83.5	5.18 Y	55.3	1.2	54.0	22.5	31.5	58.3	1.3	4.0	5.3	64.6
3	In oven at 125-154°F.	17.50 hrs.	83.1	6.07 Y	55.9	1.3	54.6	21.3	33.3	61.0	1.7	3.3	5.0	65.0
4	Spread 4-6 inches deep on screens in attic. Daytime temperatures 81-118°F.	4 days	83.8	7.04 Y	55.1	1.3	53.9	20.6	33.3	61.8	2.1	2.5	4.6	58.8
5	Spread 4-6 inches deep on screens in well ventilated room. Daytime temperatures 82-90°F.	10 days	82.7	7.20 Y	55.2	1.3	54.0	20.1	33.9	62.8	2.2	2.2	4.4	58.2

1. Y—yellow. Munsell hue is numbered 1 to 10 for each of 10 hues: Red, Yellow-Red, Yellow, Green-Yellow, etc. IY is a reddish yellow, changing to a greenish yellow as the numbers progress toward 10Y. The sumac leaves in this study vary from a yellow at 5Y to greener yellows at 6Y and 7Y.
2. The material extracted consisted principally of leaves with few, if any stems. All analytical results reported on moisture free basis.
3. Purity of extractive is 100 times percentage of tannin divided by percentage of soluble extractives.
4. Percentage reflectance for green light of sheepskin skivers tanned directly with ground leaf; reflectance versus MgO, 45° incidence, normal viewing. Each value is an average of measurements of duplicate skivers.

TABLE II

Results of Leaf Analysis and Tanning Tests on Sheepskin Skivers of Three Species of Sumac Dried by Different Methods

		Analysis[1]					Examination of Sheepskin Skivers							
Species	Method of Drying	Insolubles in Extractives	Soluble Extractives	Non Tannins	Tannins	Purity	Skin No.[2]	Weight Yield[3]	Thickness	Voids	Tensile Strength	Stretch at 300 lbs. per sq. in.	Combined Tannin	Reflectance at 546Mμ[4]
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent		Per Cent	cm.	Per Cent	lbs. / sq. in.	Per Cent	Per Cent	Per Cent
R. copallina (dwarf sumac)	(1) In steam heated drier[5]	2.0	49.5	21.2	28.3	57.2	1L, 2R	42.0	0.0784	74	642	5.7	28.6	50.4
	(2) Spread in thin layer on wooden, second story floor.[6]	2.5	49.9	20.7	29.2	58.5	1R, 2L	47.2	0.0884	72	533	7.4	31.6	47.6
	(3) Spread in thin layer in room maintained at 70°F. and 50% humidity.[7]	2.7	50.6	21.2	29.4	58.1	—	—	—	—	—	—	—	—
R. glabra (white sumac)	(1) See under *R. copallina*	1.9	47.5	20.4	27.1	57.0	3L, 4R	39.7	0.0775	72	611	4.2	27.2	57.1
	(2) See under *R. copallina*	2.2	47.7	20.2	27.5	57.7	3R, 4L	44.0	0.0814	74	595	8.3	29.0	52.6
	(3) See under *R. copallina*	2.5	48.6	20.5	28.1	57.8	—	—	—	—	—	—	—	—
R. typhina (staghorn sumac)	(1) See under *R. copallina*	2.2	48.2	19.9	28.3	58.7	5L, 6R	45.0	0.0869	72	613	3.6	31.8	55.5
	(2) See under *R. copallina*	2.5	49.1	20.2	28.9	58.9	5R, 6L	48.3	0.0844	68	588	3.6	31.0	51.4
	(3) See under *R. copallina*	2.3	50.1	20.4	29.7	59.3	—	—	—	—	—	—	—	—

[1] On moisture free basis.

[2] R indicates right, L, left side of a skin; e.g. 1 R and 1 L are opposite sides of the same skin.

[3] Weight of washed leather as percentage of pickled skin weight.

[4] Percentage of reflectance for green light of sheepskin skivers tanned directly with ground leaf; reflectance versus MgO, 45° incidence, normal viewing.

[5] Drier heated to 188°F. and leaves then placed on trays; drying continued for 40 minutes when all leaflets were dry but petioles tough. Temperature ranged from 170° to 184°F. When *R. glabra* leaves were dried the temperature ranged from 158° - 160°F. Leaves removed after 35 minutes and dried overnight on trays. *R. typhina* leaves handled like *R. copallina* leaves required 60 minutes to dry.

[6] Leaves were placed on floor on September 5, turned twice and removed fully dry on September 12.

[7] Same as above but the leaves were probably dry somewhat sooner.

For the skiver tests six sheepskin skivers were cut down the backbone line to form 12 sides. One side of each skiver was tanned with sumac dried in the drier and the opposite side with sumac dried in the barn. Six additional skivers were tanned in which opposite sides were tanned with sumacs of different species. Although this gave a comparison of drying methods only on different skivers, the results were consistent with and therefore support those reported here. These results may be summarized as follows: For *R. copallina* and *R. glabra*, weight yield, thickness and stretch are lower for the steam dried material than for the floor dried but the color and tensile strength are higher. Combined tannin is low and is mainly responsible for the low yield. For *R. typhina*, weight yield is low but thickness, tensile strength and color are better for the steam dried material while there is no difference for stretch and combined tannin. Weight yield is not of much importance as the tanner sells this type of leather by the square foot. The steam dried material is definitely better for *R. typhina*. Which method is better for the other two species might depend on the use to which it was put. For some leathers color would be important enough to make the steam dried material preferable but for other leathers in which stretch and thickness are more important than color, slow drying would be preferable.

Practical Field Methods. Experiment 3: In 1943 a series of drying tests were conducted at Beltsville, Maryland, with dwarf sumac and elsewhere in the State with white and staghorn sumac to demonstrate the relative efficiency of several methods that can be utilized with the structures or equipment that are generally available on the farm. Outdoor and indoor tests were included. The success of drying the sumac outdoors will naturally depend on the kind of weather that prevails and the tests were made to determine how long a period of good drying weather is required to complete the drying by certain procedures. The procedures followed and the results obtained are shown in Tables III and IV.

The dwarf sumac, except that used in test No. 13, was obtained from wild plants growing in various places at Beltsville. It consisted of branches of the season's growth ranging from one to four feet in length. In order to secure comparable material for the tests the entire quantity was divided branch by branch into 11 piles which were then used in the several ways described in the tables for the tests numbered 1 to 11. For test No. 12 a larger quantity was required. This was obtained mainly from cultivated plants which were cut with a hay mower supplemented with a smaller amount gathered from wild plants growing along roadways. A total of 1580 pounds was used for test No. 12.

Drying in the swath or windrow would involve the least work if the crop is grown under cultivation and is cut with a mower. With good drying weather prevailing, as was the case in these tests, complete drying can be accomplished in 5 or 6 days. However, when completely dry considerable

TABLE III

Comparative Results of Drying Leaves and Small Stems of Three Species of Sumac by Practical Outdoor and Indoor Methods Showing Rate of Loss of Moisture and Color of Leaves when Dry

Species and Test No.	Method of Drying	Weather Conditions[1] and Condition of Material as Drying Progressed	Per Cent of Moisture after the Number of Days Indicated							Color[2]
			Start	2	4	5	7	11	14	
R. copallina										
1	In swath	Cut Aug. 12. Light rain second day. Leaflets and petioles brittle in 4 days. Moved into barn after 5 days. Bleached.	57.0	—	6.9	—	—	—	—	2.16 Y
2	In windrow	Cut Aug. 12. Light rain second day. Dry in 4 days except parts in contact with ground. Moved into barn after 5 days. Bleached.	57.0	—	13.4	—	—	—	—	4.29 Y
3	In windrow after partial drying in swath	Cut Aug. 12. Light rain second day. After 4 days condition much like lot 1, but slightly tough near ground. Moved into barn after 5 days. Bleached.	57.0	—	12.1	—	—	—	—	3.25 Y
4	Tied in bundles 8 to 12 inches in diameter and shocked 7 bundles to a shock	Cut Aug. 12. Light rain second day. After 4 days bundles cool throughout. Leaflets on outside of bundles brittle and bleached. No drying in interior of bundles. Slight blackening of leaf tips in spots. Moved into barn after 12 days when there was some blackening in center of bundles.	57.0	42.0	—	24.0	21.7	9.8	9.7	5.00 Y
5	Tied in bundles 8 to 12 inches in diameter and shocked 11 bundles to a shock	Cut Aug. 12. Light rain second day. Condition about as lot 4. Moved into barn after 12 days when there was much blackening in center of bundles.	57.0	42.0	—	26.3	25.0	11.1	10.6	5.17 Y

TABLE III (Continued)

Comparative Results of Drying Leaves and Small Stems of Three Species of Sumac by Practical Outdoor and Indoor Methods Showing Rate of Loss of Moisture and Color of Leaves when Dry

Species and Test No.	Method of Drying	Weather Conditions[1] and Condition of Material as Drying Progressed	Per Cent of Moisture after the Number of Days Indicated: Start	2	4	5	7	11	14	Color[2]
6	Piled loosely in cocks after partial drying in swath	Cut Aug. 12. Light rain second day. Drying progressed as in lot 3. Moved into barn after 5 days. Bleached.	—	—	—	—	—	—	—	4.65 Y
7	Placed in cock with center pole with cross pieces about 6 ins. from the ground	Cut Aug. 12. Light rain second day. After 4 days very uniform throughout; leaves brittle and stems tough. Moved into barn after 5 days. Most of the green color retained.	57.0	26.2	—	—	—	—	—	6.05 Y
8	In barn on wooden floor near ground in thin layer 6 to 8 inches deep	Cut Aug. 12. Removed after 27 days but was probably dry enough somewhat earlier.	57.0	—	—	—	31.7	13.9	12.1	4.69 Y
9	In barn on wooden floor near ground in thick layer 12 to 16 inches deep	Cut Aug. 12. Removed after 27 days. Some portions still somewhat tough.	57.0	44.8	—	26.0	34.0	15.2	15.2	4.44 Y
10	In barn on wire rack about 5 ft. from the ground in thin layer 6 to 8 inches deep	Cut Aug. 12. Removed after 27 days. Probably dry enough somewhat earlier.	57.0	—	—	14.0	7.4	11.5	11.5	5.00 Y
11	In barn on wire rack about 5 feet from the ground in thick layer 12 to 16 inches deep	Cut Aug. 12. Removed after 27 days. Dry.	57.0	46.7	—	20.0	23.1	15.6	13.9	4.62 Y
12[3]	Packed firmly in bin to depth of 5 feet. Air blown in continuously through a duct along the center at the bottom as in hay driers	Cut Aug. 14. Blower operated continuously until Sept. 3. Some portions which did not receive sufficient aeration had turned dark and were removed.	57.0	56.9[4]	49.1 34.7[5] 18.6[6]	41.3 19.6 13.3	40.5 26.7 9.4	27.5 11.1 10.3	17.6 11.8 9.1	5.43 Y

		Darkened portion removed from above. [12 (b) in Table IV]								3.93 Y
13	In thin swath in field as cut by mower	Cut. Aug. 13. Rained on once. Shocked Aug. 19. Removed Aug. 20 completely dry. Brown color.	—	—	—	—	—	—	—	0.0 Y
R. glabra										
14[7]	Spread loosely several feet deep on wooden floor in rooms of one story frame building	Two lots cut between Aug. 19 and Sept. 7. The combined lots remained undisturbed for some time after they were fully dry. The first lot was partially dry when the second was placed on top of it.	—	—	—	—	—	—	—	5.00 Y
R. typhina										
15[8]	Under roof about one week, then several weeks on outdoor rack under tarpaulin.	Dried poorly under roof; darkened portions discarded when material was removed to rack.	—	—	—	—	—	—	—	7.14 Y

1. Detailed data on temperatures, humidity and hours of sunshine were not recorded. Throughout the time when material was drying outdoors the weather was clear and favorable for drying except for a brief light rain on the second day.
2. See footnote 1, Table I.
3. The material for lot 12 was derived from a different source than that used for lots 1-11; it contained larger stems.
4, 5, 6. Moisture in material at the top, middle, and bottom of the bin, respectively.
7. This material was used in the comparative tests of Silician and American sumacs and is designated Lot E in reference 3.
8. This is the material designated Lot K in reference 3.

TABLE IV

Comparative Results of the Analysis of Leaves of Three Species of Sumac Dried by Various Methods and under the Conditions Described in Table III

Species and Test Number[1]	Method of Drying	Analysis[2]										Color Measurement of Sheepskin Skivers	
		Total Extractives	Soluble Extractives	Insolubles in Extractives	Non Tannin	Tannin	Purity	Sugars: Non-reducing	Sugars: Reducing	Sugars: Total	pH	Per Cent Reflectance[3]	Rank—Lightest to Darkest
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent			
R. copallina													
1	In swath	48.1	46.9	1.3	21.6	25.3	54.0	1.5	5.5	7.0	3.8	55.5	3
2	In windrow	46.4	45.3	1.2	20.5	24.8	55.0	1.6	4.8	6.4	3.9	–	–
3	In windrow after partial drying in swath	47.0	45.0	1.0	20.8	24.2	53.9	1.5	5.0	6.5	3.9	54.0	7
4	Tied in bundles 8 to 12 inches in diameter and shocked 7 bundles to a shock	48.5	47.3	1.2	17.6	29.7	63.1	1.9	3.0	4.9	4.1	52.3	8
5	Tied in bundles 8 to 12 inches in diameter and shocked 11 bundles to a shock	45.0	43.7	1.3	17.3	26.4	60.5	1.6	2.9	4.5	4.1	50.0	12
6	Piled loosely in cocks after partial drying in swath	46.9	45.7	1.2	29.0	24.8	54.3	1.8	5.1	6.9	3.9	55.0	5
7	Placed in cock with center pole with cross pieces about 6 inches from the ground	48.9	47.5	1.4	20.1	27.4	57.7	2.2	4.1	6.3	4.0	54.2	6

8	In barn on wooden floor near ground in thin layer 6 to 8 inches deep	49.5	48.3	1.2	18.0	30.3	62.8	1.5	3.4	4.9	4.1	50.8	10
9	In barn on wooden floor near ground in thick layer 12 to 16 inches deep	46.8	45.7	1.2	16.6	29.1	63.6	1.6	2.5	4.1	4.3	50.2	11
10	In barn on wire rack about 5 feet from ground in thin layer 6 to 8 inches deep	48.0	46.8	1.2	18.5	28.3	60.5	1.9	3.5	5.4	4.1	55.3	4
11	In barn on wire rack about 5 feet from ground in thick layer 12 to 16 inches deep	46.8	45.6	1.2	17.0	28.6	62.7	1.7	2.7	4.4	4.2	52.0	9
12	Packed firmly in bin to depth of 5 feet. Air blown in continuously through a duct along the center at the bottom as in hay driers	(a)[4] 49.9 (b)[5] 45.3	48.3 43.8	1.6 1.6	18.6 14.8	29.7 29.0	61.5 66.2	2.1 1.7	3.3 1.2	5.4 2.9	4.0 4.2	58.2 48.6	1 13
13	In thin swath in field as cut by mower	46.9	45.8	1.1	20.5	25.3	55.3	1.4	4.7	6.1	3.9	57.0	2
R. glabra													
14	Spread loosely several feet deep in rooms of one story frame building	45.3	43.6	1.7	18.0	25.6	58.8	2.0	2.1	4.1	4.4	45.0	–
R. typhina													
15	On outdoor rack	38.9	37.1	1.8	18.1	19.0	51.2	1.3	3.0	4.3	4.5	49.8	–

1. Test Nos. correspond to those in Table III.
2. Analysis on moisture free basis.
3. Reflectance for green light (546 millimicrons) of sheepskin skivers tanned directly with ground leaf; reflectance versus MgO, 45° incidence, normal viewing. Each value is an average of measurements of duplicate skivers.
4. Well cured.
5. Poorly cured, blackened.

shattering may result when the material is gathered up. Drying it partially in the swath or windrow and piling it in cocks would reduce this loss to some extent. When exposed to the sun in the swath all the leaves are bleached so that little green color remains, as indicated by the color measurements shown in Table III. The greatest bleaching took place in the swath, the next greatest when partial drying in the swath is followed by further drying in windrow. Drying completely in the windrow and drying partially in windrow followed by further drying in loose cocks resulted in about the same degree of bleaching. The least bleaching outdoors is obtained when the freshly cut or broken branches are placed in cocks with center pole and cross pieces just above the ground as described in test No. 7. This method also resulted in rapid drying but requires relatively more labor than the methods referred to above. Tying the branches in bundles and shocking these like grain gave poor results because drying proceeded very slowly in the interior of the bundles and much discoloration took place. On the outside there was much bleaching. Better results could probably be obtained if the bundles are tied very loosely. Harvesting the cultivated crop with a grain or corn harvester would be entirely practical if drying in the shocked bundles can be satisfactorily accomplished.

The indoor test with dwarf sumac included drying in thin and thick layers on a wooden floor and on a wire rack. The material was stirred or turned once in the early stage of drying. It was not removed until after 27 days but that on the wire rack and in the thin layer on the wooden floor was dry much earlier. The moisture content after 14 days was about that of the material dried 4 days in the windrow in the field. The rate of drying is naturally somewhat more rapid on a wire rack and in a thin layer than on a wooden floor or in thicker layer.

The result obtained by the use of the principle of a hay drier in test No. 12 was inconclusive. The air duct was not properly designed and consequently there were dead spots in the bin where the sumac dried very slowly, resulting in some blackening. The moisture content at intervals at three levels indicate that the portions at the bottom and in the middle of the layer were sufficiently dry to be removed in about 11 days. When the material was removed after the blower had been operated continously for 20 days the discolored portions were separated and submitted separately for anlysis.

At about the same time it was possible to observe the rate of drying of dwarf sumac in an open field where it had been cut down with a mower together with various weeds It was cut on August 13 and placed in loose piles like hay on August 19, after one shower of rain had fallen on it. On August 20 it was removed, completely dry. This material was of a uniform brown color, having lost all trace of green as shown by the color reading.

Some limited tests with white and staghorn sumac were made in connection with an attempt to secure large quantities of the leaves and branches of these species in Washington County, Maryland, for commercial tests on skins as described by Clarke, Mann and Rogers [3]. White sumac was collected in two lots from various fields during the period August 19 to September 7 in the Hagerstown, Maryland, area. The first lot was piled about 3 feet deep on the floors of several rooms of a one-story wooden building with ample ventilation. The second lot was deposited on top of the first layer after the latter had dried considerably. The material was not turned or disturbed. There was no opportunity to watch the progress of the drying closely and the time required is therefore not known. It was not removed until sometime after the material was entirely dry. (No. 14 in Tables III and IV.). The leaves were then separated. In color they compared with that dried in a thin layer on a wire rack in a barn at Beltsville. With the exception of a small portion of it used for analysis and skiver tests this lot was used in these large scale tanning tests.

The staghorn sumac used in these tests was collected during the period July 27 to August 6 on the south slope of a mountain in Washington County, Md. Part of this lot was piled on the cross joists under the roof of a large garage with open doorways and the remainder stood upright around the side walls. Lack of adequate ventilation resulted in some heating and discoloration of the material under the roof and after about one week it was removed, most of the discolored parts discarded and the remainder together with that which had been placed around the walls and which was drying satisfactorily, was then placed in a single large stack outdoors on a wooden rail base about one foot from the ground (No. 15 in Tables III and IV). In this condition it remained for sometime until it was removed, the stems separated and the leaves sent to the commercial tannery for the tests mentioned.

A study of the analytical data and the color readings on the sheepskin skivers (Table IV) clearly show that quality of leaf as indicated by tannin content has no relation to quality based on the color of the skins tanned with the leaf. The tannin content of the several lots of dwarf sumac also appears to bear no rational relation to the kind of treatment. Rapid drying in sunlight in the swath (No. 1) and in windrow (No. 2), and by a combination of these (No. 3) and partial drying in the swath followed by additional drying in cocks (No. 6) resulted in a low tannin content. No. 13 also gave a low tannin content but the material used was from a different source. Drying slowly on a wooden floor indoors (Nos. 8 and 9) and in the bin with forced draft of unheated air (No. 12-a) furnished material with the highest tannin content. The portions in the bin that did not get adequate aeration, due to faulty design of the air ducts (No. 12-b) and which had turned dark likewise had a relatively high tannin content. The material dried slowly on wire racks indoors (Nos. 5, 10 and 11) also contained a fairly high percentage of tannin. Nos. 4 and 5 in which the sumac branches were dried outdoors in tight bundles in shocks of 7 and 11 bundles, respectively, the dried leaves of the smaller shock had a tannin content of 29.7 per cent and those of the larger shock

26.4 per cent. The reason for this difference is not found in the rate of progress in the drying because it is shown in Table III that the rate of reduction in moisture content did not differ greatly. The skivers tanned with the leaves from these two treatments had considerable color, indicating deterioration took place during the drying and that it occurred to a greater degree in the larger shock. It appears in this case that this greater deterioration resulted in a loss of tannin but such a relationship is not indicated in tests 12-a and 12-b.

The non tannins were definitely higher in the leaves dried quickly outdoors (Nos. 1, 2, 3, 6, and 7). Slower drying in the shocks outdoors resulted in somewhat less non tannin and very slowly dried and partly deteriorated portions of the material in the bin contained only 14.8 per cent as compared with the 18.6 per cent in the better aerated portion. These results are in agreement with those obtained by Clarke and Hopp[2] indicating that slow drying results in low non tannin values and dark skivers. They are not altogether in agreement on the effect of tannin content, however, for Clarke and Hopp found that the different methods they used had no influence on tannin content.

The single lot of white sumac collected and dried in western Maryland had a good tannin content but the amount of color in the skiver tanned with it indicates only relatively fair quality. In the case of the single lot of staghorn sumac collected in the same general region the tanning test revealed poor quality and the tannin content is much too low to make such material acceptable. However, these tests of single lots should not be considered conclusive and provide no reliable indication of the relative value of these species.

Experiment 4: In 1941 extensive tests on the drying of dwarf sumac were made at the Beltsville Research Center, Beltsville, Maryland, in specially constructed outdoor racks and a stove-heated kiln. The principle followed in these drying tests was to provide free circulation of air beneath and through the sumac during the curing and to keep the material from becoming wet during and after the curing. The following three types of drying equipment were used:

(1) An open-air rack 6 x 16 feet, built of dead pine poles. Woven wire chicken fencing stretched over poles 3 feet above ground formed the bed of the rack. It held 500 pounds of green sumac and cost $3.00 for labor and materials. Heavy canvas tarpaulins covered the rack at night and whenever rain threatened. The sumac was stirred each morning to provide good aeration.

(2) A covered drying rack consisting of 4 tiers of shelves, 16 feet long and 3.5 feet wide. The framework was of 2 x 4 inch pieces with uprights 7 feet high at each end of the rack. The lowest shelf was 2 feet above the ground, with 18-inch spacing between the bunks above it. Lengths of 10-wire hog-fencing, supported by slats laid across the bunk, held the sumac, spread 10-12 inches deep on the shelves. Two such rack units were placed side by

side and their framework extended to hold a lightweight tarpaulin serving as a projecting roof. Each rack unit of 4 shelves held 500 pounds of green sumac. The cost, including the tarpaulin, was around $35 for a 4-shelf rack in 1941. Such racks will last 3 or more years if the tarpaulin is removed and stored indoors over winter. Corrugated iron roofing would be better than canvas if the supports were strong enough to bear the weight of winter snows. The sumac on the shelves was stirred or "riffled" each morning to prevent uneven drying. It is unnecessary to completely turn over the material when air circulates freely beneath and above it as on shelves of this type, but "riffling" speeds drying.

(3) A portable, homemade dry kiln which cost $64 for labor and materials. The kiln was 6 feet square and 8 feet high, constructed of galvanized sheet-iron nailed to 2 x 3 foot frames to form panels. A bin 6 x 6 x 3 feet at the top of the kiln held 400 pounds of green sumac. The floor of the bin was link fencing, 1-inch mesh, laid over 2 x 4-inch sills. A chuck-wood stove of heavy iron was set on the ground in the center of the kiln, and sheet-tin between the stove and bin was so arranged as to permit free circulation of air. The tin sheets intercepted leaves as they fell through the floor of the bin, causing them to slide into asbestos-covered wooden troughs at the sides of the kiln. The kiln had two removable sheet-iron frames for a roof, and a removable half-panel gave access to the stove and the cured leaves. The kiln was bolted together so as to make it readily portable, and was substantial enough to last many years. Drying in this kiln would have been more rapid if the floor of the bin had been built like the grate of a stove, so that when it was moved by a lever outside the bin, the sumac would be shaken to facilitate air circulation.

The sumac was spread on the drying racks or placed in the kiln within two hours after gathering because the first lot collected discolored and had to be discarded after remaining in piles for 3 hours on a very hot day.

On the open-air rack described under (1), on which the sumac was exposed to the sun, it dried in 3 to 5 days if piled about one foot deep, depending on weather conditions. On the shaded rack described under (2) from 5 to 7 days are required for drying similar material piled to the same depth if fair weather prevails. In clear, very dry weather only 4 days are required.

On the covered racks the sumac dried uniformly bright green in color. On the uncovered racks, sunshine faded the top leaves, but since these formed only a small part of the total there was no marked difference in color between leaf material produced by the two types of drying racks. There is little danger of the leaves molding on racks like these if the material is only a foot deep and is riffled daily, and if rain is kept off by the means described. A farmer having no tarpaulins can secure similar drying results by setting up the racks inside his barn, leaving the doors open for free circulation of air.

Most of these test lots were first air-dried for some time in one or the other of the outdoor racks described, and the curing process then completed in the kiln at temperatures averaging around 149° F. Only two large lots were kiln-dried immediately after collection; nine lots were first partially air-dried and then kilned. The object in those cases was to remove most of the water by air drying and then kiln dry the material to facilitate separation of the leaves from the stems.

It is more economical to remove water from green material by air-drying than by the use of artificial heat. To produce 100 pounds of dry sumac leaves an average of 358 pounds of green sumac including stems was required, 221 pounds of which was water that had to be evaporated. The normal moisture content of fully air-dried sumac is about 7 per cent. Numerous tests showed that the kiln evaporated water at the rate of 3.8 pounds per hour of kiln operation. To evaporate the 221 pounds of water by kiln required 0.66 cords of fuelwood (0.0115 cord per kiln hour). To produce the 100 pounds of dry leaf by preliminary air-drying followed by kiln-drying only 19 pounds of water had to be evaporated in the kiln, requiring 5 hours of kiln operation with 0.06 cord of wood. Hence, preliminary air-drying saved 0.6 of a cord of wood for each 100 pounds of leaf cured. It also reduces the cost of labor in firing the kiln.

In these drying tests on dwarf sumac cost data were obtained which give some general indication of the relative cost of air and kiln-drying. The cost of drying required to yield a ton of marketable sumac was found to be almost three times as high by the kiln-drying as by the air-drying method, but the cost records covered the handling of only limited quantities and should therefore not be considered conclusive. When kiln-drying is conducted with good organization to permit the most efficient use of labor and fuel the cost differential between the two methods would no doubt be reduced. Even air-drying costs were found to be too high for a material having a market value like that for which sumac generally sells in this country. However, a farmer or collector who can thus employ otherwise unused labor in the family and does not have to hire labor for the purpose at prevailing rates can conduct these operations at a much lower cash outlay than these experiments indicate. The most important single item of cost in kiln-drying in these experiments was the fuel. On a farm this cost would naturally vary greatly according to whether the fuel, when wood is used, must be purchased or is available on the farm in a form in which it is generally not readily marketable.

Ten lots comprised the main tests on comparative air and kiln drying. These were collected and treated between August 7 and September 26. From October 13 to 21 eight additional tests were made on small lots. These were obtained by dividing into two equal portions four lots collected in 4 different areas where the sumac still remained green in October. In each case one of the portions was air-dried and the other kiln-dried. The results of the chemical analysis and skiver tests of these and the ten main lots are shown in Table V.

TABLE V

Results of Chemical Analysis and Skiver Tests of 18 Lots of Dwarf Sumac Dried in Various Ways

No. of Lots*	Method of Drying	Results of Laboratory Tests: Color of Leather Produced	Average Per Cent Tannin	Average Per Cent Non Tannin
2	Kiln-dried only	Good (light)	25.7	23.2
1	Kiln-dried only	Medium	27.4	20.6
3	Kiln-dried only	Poor (dark)	26.2	19.4
2	Air-dried, then kilned	Good (light)	24.8	23.0
5	Air-dried, then kilned	Medium	27.3	21.6
1	Air-dried, then kilned	Poor (dark)	24.1	20.8
2	Air-dried only	Good (light)	23.7	24.1
2	Air-dried only	Medium	25.4	23.7

*The six lots dried entirely in the kiln included the two large lots dried during the period in August and September when most of the tests were made and four smaller lots collected in October.

It will be noted that each method of drying used in this series of tests produced some lots of cured leaves that tanned leather of satisfactory light color while other lots produced leather of medium to dark color. Again, as was noted in Experiment 3, no relation is evident between color of leather and tannin content but dark color is associated with low non tannin content and slow rate of drying. Slow drying may result if the material is packed so tightly in the bin that free circulation of hot air is impeded. For example, in one test 164 pounds of green leaves was dried in the kiln bin (6 x 6 x 3 feet.) in 30 hours, whereas 442 pounds in another test required 77 hours to dry because the heated air could not circulate freely through compacted portions of the green material during the first two days of drying. Material from the first test contained 23.7 per cent tannin and 22.3 per cent non tannin and produced the lightest colored leather obtained in any of the major tests. Leaves from the second test contained 25.1 per cent tannin and 18.5 per cent non tannin and produced the darkest colored leather of the series. Improper functioning of the stove caused poor quality in one lot. These results emphasize the fact that dwarf sumac leaves must be dried quickly and uniformly to produce a satisfactory product.

Removal of the stems is necessary to produce sumac tanning material of uniform quality. The leaflets represent the purest grade. Kiln-drying facilitates the separation of the leaves from the stems and of leaflets from midribs and petioles. However, if the material can be obtained sufficiently dry by air-drying such separations can be more cheaply accomplished with a threshing machine.

In connection with the foregoing experiments some data were obtained on the rate at which this sumac can be collected under various conditions and by various methods. Since the cost of collection of the green material is a major item in the cost of producing sumac leaf for the market, the conclusions that were drawn from these data are of interest. They are summarized as follows: Machine harvesting offers a promising means of reducing the cost of collection if the sumac stands are accessible, reasonably dense over large areas and practically free from briars and weeds. These favorable conditions seldom are found where sumac grows wild, but can be assured by the systematic culture of the plant. Under the usual conditions of wild growth, the old time method of hand-breaking sumac is good practice, and collecting 100 pounds of green material per hour of work is a fair average. A large, lightweight container, into which the sumac is tossed as it is broken, saves time in collecting by hand and makes the work easier. Sumac sprouts 2 to 5 feet tall are favorable for rapid collection of green material. Native growth sumac can be improved for hand or machine collection if the brush is mowed every other year to encourage production of sprouts.

Use of Commercial Equipment. Experiment 5: In south central Virginia where sumac has long been collected for the market considerable tobacco is grown. In the handling of tobacco in warehouses it is a common practice to thoroughly dry the leaf previously cured on the farm and then "recondition" it by adding a certain amount of moisture. One type of equipment used for this purpose is a large, steam heated, tunnel-type drier. When used in handling tobacco this equipment is generally idle much of the time and it seemed possible that when not otherwise in use it might be used for drying sumac where this is collected or grown in the community. To determine its usefulness for this purpose several test runs were made with such a drier with leaves and branches of dwarf sumac at Farmville, Virginia.*

The drier is 120 feet long with three chambers, first a 60-foot drying chamber which can be maintained at temperatures up to 250°F, second a 20-foot cooling chamber, and finally a 40-foot humidifying chamber.

The material is fed onto a wide slowly moving wire mesh belt which travels at such a rate that from 30 to 40 minutes is required for the material to emerge at the other end. If there is no other purpose than the removal of moisture only the first chamber is concerned in the operation and the material being dried is subjected to the high temperatures while passing through this chamber. Thereafter, as it passes through the other two chambers it cools rapidly.

The dwarf sumac was collected in a nearby area.† It consisted almost entirely of relatively small branches and was therefore considerably less woody than is frequently the case. The branches were distributed at random into three 200-pound lots and one lot of 68 pounds. The purpose of these tests was to determine the minimum time necessary to dry the material when

*Credit is due J. L. Putney & Sons, who made their drier available for the purpose and provided the personnel necessary to operate it.

†Permission was obtained to collect the sumac on State land and credit is due officials of Civilian Conservation Corps Camp at Cumberland, Virginia, for providing the necessary personnel and truck.

subjected to the highest temperature attainable in the drier. The first lot of 200 pounds was placed on the traveling belt 4 to 6 inches deep. The 38 minutes required for it to travel through the drier was insufficient to dry the material as fully as desired. Adjustment to reduce the rate of movement substantially could not be made, therefore the next lot, also of 200 pounds, was spread on the belt only 3 to 4 inches deep. In this case the 38 minutes was adequate to reduce the moisture in the leaves to 4.6 per cent but the stems contained 20.2 per cent. The leaves could be readily separated by flailing. From a portion of the third lot of 200 pounds and from all of the small lots the leaves were removed and run through simultaneously in two separate portions, one spread thinly on one of the conveyor belts and the other more thickly on the second belt moving parallel to the first. The moisture content of the first portion on emergence was 3.7 and that of the second portion was 8.5 per cent. The remainder of the collected material, weighing 188 pounds, was left spread on the wooden floor of the warehouse overnight and used in the final run the next morning (Test No. 4). The moisture content of the leaves and stems on emergence was 3.0 and 19.1 per cent, respectively. The complete data are assembled in Table VI.

A comparison of the results of the analyses of the leaves dried rapidly in the drier at the high temperatures indicated and those air-dried as a control show that neither the tannin nor non tannin content was affected to any extent and that from that standpoint there is no objection to the use of such equipment in the way described for rapid drying of sumac. The dried leaves from all but Test No. 4 were tested on cowgrain skivers to note the effect on the color of the leather. Of the three rapidly dried samples tested, those from Test Nos. 1 and 3 gave the lightest color and that from Test No. 2 gave the darkest, but the air-dried sample gave a darker color than any others. The thickness of the layer of leaves on the drier belt apparently is not a factor since the leaves dried in Test No. 3 gave less color to the skiver than those of Test No. 2. It appears from this that from the standpoint of the color produced in the leather the rapid drying accomplished by this drier is not objectionable and that the full capacity of the drier may be utilized.

Since the cost of operating the drier is relatively large it must have a large capacity to reduce the cost of drying sufficiently for a product of relatively low market value. Although no attempt was made to keep an accurate cost record during these tests those familiar with the operation of the equipment in the handling of tobacco concluded that cost of drying the sumac by this method would be too high to permit its use at prevailing market values of the product.

Conclusions

In general, the experiments with dwarf sumac, *Rhus copallina*, show that rapid drying at elevated temperatures causes a slight but not serious loss of tannin; the loss being about 1 per cent. Non tannin is affected very little

TABLE VI

Results of Tests on Drying Sumac in Commercial Tobacco Drier and Conditioner

Species and Test No.	Kind of Material Used	Depth of Layer	Quantity Used	Time Required to Pass Through Drier[1]	Rate of Feed into Drier	Range of Temperature in Heated Chamber[2] Minimum	Range of Temperature in Heated Chamber[2] Maximum	Moisture on Emergence from Drier Part	Moisture on Emergence from Drier Per Cent	Results of Analysis[3] Total Extractives	Soluble Extractives	Insolubles in Extractives	Non Tannin	Tannin	Purity
			Pounds	Minutes	Pounds / Hour	°F.	°F.			Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Dwarf Sumac															
Control	Leaves									51.2	49.7	1.5	21.3	28.4	57.2
1	Leaves and stems	3 to 4 ins.[4]	200	38	407	204	242	Leaves Stems	4.6 20.2	51.9	50.7	1.2	22.4	28.3	55.8
2	Leaves	Very thin	32.5	38	244	200	258	Leaves	3.7	51.8	50.1	1.7	21.7	28.4	56.7
3	Leaves	Thick	32.5	39	650	[5]	—	Leaves	8.5	54.2	52.0	2.2	22.4	29.6	56.9
4[6]	Leaves and stems	Thin	188	41	490	196	250	Leaves Stems	3.0 19.1	54.1	52.4	1.7	22.1	30.3	57.8
White Sumac															
5	Leaves and stems	Thin	3.5	40	—	[5]	—	Leaflets Petioles Stems	2.1 10.6 24.3	52.8	51.3	1.5	21.5	29.8	58.1

[1] This is the time required for the material to emerge from the drier. It passes through the heated drying chamber, one-half the length of the tunnel in one half of the time required to emerge.

[2] These are the temperatures registered in the 60-ft. drying chamber; thereafter temperatures drop rapidly; material is cool as it emerges from drier.

[3] Results calculated on moisture-free basis.

[4] In a first run not recorded here, using the same quantity and the same temperatures but with the layer 4 to 6 inches deep, the drying was inadequate in 38 minutes.

[5] Temperatures were not recorded but probably were about the same as in the previous tests because the leaves were placed on the belt immediately following those of test No. 3.

[6] The material used in this test had been spread out on the wooden floor of the warehouse overnight. Very little moisture was lost during the night.

although these is an indication that it may be increased by a trifling amount. Artificially dried sumac produced lighter colored leather than sumac dried more slowly, but leather yield and the combined tannin in the leather were both low. The artificially dried material, therefore, would produce leather that was not as well tanned as leather from air dried sumac and the leather would have an "empty" or slightly tinny feel as compared to the leather made from the latter.

For field or shed drying, the important factor is time. Any method is satisfactory if drying is rapid.

In a previous carefully controlled test [2] it was found that leaves that had been dried rapidly with sufficient aeration produced good, light colored leather but that if drying was slow, the leather was dark in color. Slow drying resulted in a loss of non tannin which apparently was changed to compounds that darken leather. The rate of drying did not affect tannin content. The present results are in agreement with those of this previous test. For example, in Experiment 3, the sumac dried in bundles or in thick layers was lower in non tannin than that dried in a swath or windrows and it produced darker colored leather.

Drying in a swath is excellent if the weather is ideal. During such time the leaf color fades from green to tan due to the action of sunlight but this destruction of chlorophyll results in lighter colored leather. Lot 13 (Table IV), which was cut with a mower and dried in the swath for six days during which time it lost all green color, was compared in a commercial test (3) with several other lots of sumac of various types. This swath-dried material produced one of the best lots of leather as regards feel and color.

In any region where weather conditions are uncertain drying under cover in an open shed or well ventilated barn is preferable because if the sumac is not moved to cover in the event of rain it will be lowered in quality or may even be ruined. In damp or very humid weather moderate artificial heat may be necessary in the shed to promote rapid drying.

Drying sumac in a small kiln, using wood as fuel, was found to be expensive in the limited tests made but under farm conditions with cheaper fuel and labor the cost would be considerably less. If partial air-drying is possible during several days of good weather followed by kiln-drying for a short period the cost is greatly reduced and a good quality of dried sumac is obtained.

In a tobacco drier in which the temperatures ranged from 200° to 250°F., at least 38 minutes were required to dry *Rhus copallina* leaves and petioles attached to stems in a layer 3 to 4 inches thick.

Profitable drying of sumac calls for inexpensive, standardized methods, but the equipment to accomplish this may be varied in accordance with the facilities locally available to the collector or grower.

Summary

Experiments were conducted in Maryland and Virginia with three species of sumac, *Rhus copallina*, *R. glabra* and *R. typhina* to determine the effect of various methods of drying on the tannin content, color and other characteristics of the leaf that determine its value for tanning and as a source of tannin extract. Special attention was given to the effect of drying the leaf slowly and rapidly; in the shade and sunlight; and at low and high temperatures. The experiments included some conducted in the laboratory, others in the field by methods and with equipment adapted to the average farm. One test involved the use of large commercial equipment.

References

1. Barger, E. L. and Aikman, J. M., *Agricultural Engineering*, June pp. 243-245 (1945).
2. Clarke, I. D. and Hopp, H., *J. Amer. Leather Chemists Assoc.*, **40**, 363 (1945).
3. Clarke, I. D., Mann, C. W., and Rogers, J. S., *ibid.*, **41**, 59 (1946).
4. Frey, R. W. and Sievers, A. F., *ibid.*, **35**, 647 (1940).
5. Veitch, F. P., Rogers, J. S., and Frey, R. W., *Dept. Bu.* 706. *U. S. Dept. of Agric.*, April, 1935.